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Distribution of bivalve resources in Kandleru Estuary, Krishnapatnam Basin, Nellore District, Andhra Pradesh

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Kandleru River flowing north of Gudur town confluences with the Bay of Bengal near Krishnapatnam at latitude 14° 15´ N and longitude 80° 18´ E. Krishnapatnam is the southernmost minor port on the 1000 km long coastal line of Andhra Pradesh and it is just 140 km north of the city of Madras by road and about 50 nautical miles by sea. Krishnapatnam Industrial port is situated on the northern bank of Kandleru river mouth. This estuary is a dredged deep drought port, with 15 m depth extending for about 2 km to facilitate handling cargo ships and even entry of large ships. The port area and its vicinity are relatively underdeveloped and sparsely populated.

Bar-mouth of Kandleru Estuary is open throughout the year and maximum width is about

300 m. The estuary having a branch on the northern side just parallel to the shore, turn towards west with rich mangroove vegetation on either side and reaches up to the Krishnapatnam village. At a distance of 300 m from the bar-mouth, the estuary widens broadly having a maximum width of about 800 m and then slowly narrow down to 500 m at a distance of 2 km. The central part of the estuary is 15 m deep up to the port and thereafter depth decreases gradually. The Buckingham canal cuts perpendicular to the estuary at about 2.5 km distance from the bar-mouth and crosses the estuary leaving a small landscape area in the south. The estuary bifurcates into two branches on the western side of the Buckingham canal. The largest branch takes a southern turn and the smaller one towards right. Both the branches join together near Lingapuram village leaving two large islets with rich mangroove vegetation.

Materials and methods

The estuary was surveyed during 2004 from the bar-mouth up to Lingapuram village which is about 8 km to the south. Totally 16 stations were fixed at about 500 m distance each (Fig. 1). A quadrat of 50 x 50 cm was used for this survey. In each station, quadrat was placed on the molluscan bed and all the biomass present inside the quadrat were collected. The bivalves were segregated up to species level and the number of bivalves in each category was weighed separately. The bivalves were shucked, the meat removed and weighed separately. Smear was prepared from gonad to study the stages of maturity. From each station a maximum of three samples were taken and the data were pooled. The biomass is represented by raising the quadrat mass to one square meter and then multiplied by the total area of distribution.

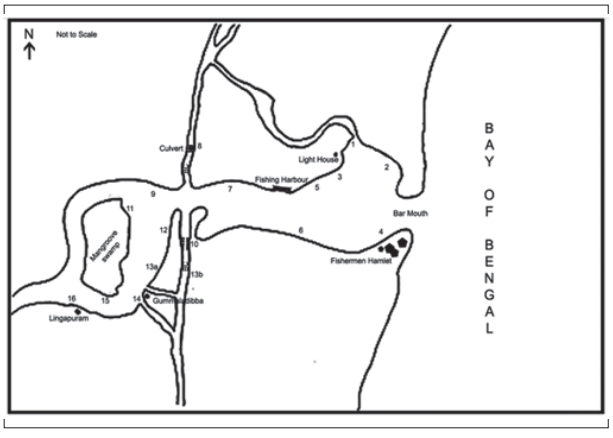

Fig. 1. Diagramatic representation of Kandleru Estuary, Krishnapatnam Basin, Andhra Pradesh

Results

Kandleru Estuary was having rich bio-resources of bivalves throughout the estuary. Table 1 gives the potential resources of bivalves and their abundance in Kandleru Estuary which comprised of *Meretrix casta, Anadara granosa, Meretrix meretrix, Crassostrea madrasensis, Marcia opima* and *Perna viridis*. Among the bivalves, the clam *M. casta* was found to be dominant and the estimated biomass was 283.3 t in a total area of 41.4 ha which constituted to 52.7% of the total bivalve resource of the estuary.

Table 1. Extent of bed and biomass of bivalves in Kandleru Estuary

Name of bivalves	Area (ha)	Biomass (t)	Percentage
Meretrix casta	41.4	283.8	52.7
Meretrix meretrix	19.3	64.6	12
Anadara granosa	40.9	112.9	20.9
Marcia opima	30.4	30.8	5.7
Crassostrea madrasensis	1.04	41.1	7.6
Perna viridis	6.24	5.8	1.1
Total	539		

Meretrix casta

The distribution pattern of bivalves, the extent of the bed, number of specimens present, size and mean weight and the biomass estimated are given in Table 2. The very rich bed of the clam *M. casta* was in the Buckingham canal which is about 30 m wide and 2 km long extending from the toll gate in the north to Gummaladippa in the south, where the average density of clams were 54 per m^2 in a total area of 6 ha and the estimated biomass was 145.8 t. The order of abundance of these calms in all other stations were: 1, 15, 2, 4, 3, 16, 9 and 6. The smallest clam bed was at station 6, the southern bank of the estuary with sandy mud with seaweed infested area. The bottom of the clam bed was muddy sand in majority of the places like the Buckingham canal 13a, 6, 9, 15 and 16 and it was sandy in station 2 and 3 nearer to the bar mouth. The first station is in the northern wing of the estuary just behind the light house of

Krishnapatnam basin. The width of the wing varied between 150 to 300 m with several curves. The depth in this area varied between 0.5 to 1.5 m. On either side of this estuary, mangroove shrubs have grown to a height of 2 m. The bottom was muddy sand harbouring clams in good quantities.

In general, the size range of the clam *M. casta* ranged between 39 and 55 mm and the mean size and mean weight have not shown much variations in all the stations observed. The males were found to be dominant in the population in majority of the areas surveyed. Only in one station, females outnumbered males. Both the sexes were equally represented in two stations.

Meretrix meretrix

The great clam *M. meretrix* was recorded only in 5 stations of Kandleru Estuary. The total resources of Kandleru Estuary covering a total bed area of 19.3 ha was estimated to be 64.6 t of living biomass. The highest population was recorded in station 13a which lies on the western side of the Buckingham canal. The water depth was varying between 0.5 and 2 m depth up to the islet area. The bed was having rich settlement of clam and they were in the surface of the ground. The average number of clams was 30 per m^2.

The second richest bed was found in station 15 lies in between Gummalladippa and Lingapuram villages and on the southern side of the islet. The bottom was muddy sand towards mangroove swamp. The clams were found to be distributed about 10 m away from the swampy area of the estuary. The density of clam population was 7.5 per m^2 and the biomass was calculated as 25.1 t. The size of the clams ranged between 39 and 63 mm with a mean size of 51.6 mm. Though this clam occurred near the mouth of the estuary, the population was very less. The nature of bottom was sandy mud and near the bar-mouth, the other areas like 14 and 16 have shown comparatively the same trend with mud and sand. The males were found to be dominant in the population. The gonad condition revealed 60% spent and 40% in the ripe condition.

***Anadara* sp.**

It is the second highest bivalve population of the Kandaleru Estuary and found to occur in 12 stations out of the 16 stations surveyed. The extent of the clam bed area was 40.9 ha and the total biomass which could be realized from this area was 112.9 t forming 20.9 % of the bivalve population. The thickest population was in station 4 followed by that of stations 15,2,16,3 and 1. In all other stations the population was very thin. The clam population was more or less equally represented from 1 to 4 stations, where the bottom was sandy mud or muddy with seaweeds like *Halophila* sp., *Enteromorpha* sp. and *Gracilaria* sp. The area behind the light house formed the first station, where the bottom was loose muddy. Among all the stations, the maximum quantity of clam could be harvested from 4th and 15th station where the biomass was estimated at 33.7 t and 17.2 t respectively. These clams were not found in the Buckingham canal and the culvert near Gopalpur village.

The size of the clams varied in different stations. The mean size was 50.8 mm (DVM) found in the 10th station and the smaller ones were recorded in station 3. Majority of the clams were above the size of 40 mm. Among the sexes, males were found to be dominant in the population and only in two stations (9 and 10) both the sexes were in equal proportion. Maturing individuals were found to be dominant (60 %) and both ripe and spent animals contributed to nearly 40 %.

Marcia opima

This clam was found to occur only in 7 stations out of the 16 stations surveyed. The total bed area was calculated as 30.4 ha and the total biomass which could be harvested as 30.8 t and this formed 5.7% of the bivalve population of this estuary. Of all the stations, a maximum of 10.4 no./m^2 was recorded only in station 3. The clam population was very sparse in all other beds. The population was high nearer to the bar-mouth where the tidal influx was very high and their distribution decreased moderately towards the upper reaches of the estuary.

The bottom of the clam bed was sandy mud and the clams were always found buried a few centimeters below the surface. Only adult and large sized clams ranging in size between 21 and 39 mm were recorded in stations 1, 3 and 4 whereas in the 2nd and 15th stations nearer to mangroove swampy area, the size of the clams was found to be 36-45 mm. The seed

Table 2. Distribution of bivalve resources in different stations of Kandleru Estuary

		Meretrix casta					*Meretrix meretrix*					*Anadara* sp.				
Station	Area (ha)	No./m^2	Size range (mm)	Mean size (mm)	Mean weight (g)	Total Biomass (t)	No./m^2	Size range (mm)	Mean size (mm)	Mean weight (g)	Total Biomass (t)	No./m^2	Size range (mm)	Mean size (mm)	Mean weight (g)	Total Biomass (t)
1	5.00	14.4	40-52	47.3	43.4	31.2						6.8	35-53	41.5	30.4	10.3
2	4.80	12	42-52	46.9	43.1	24.8	2	44-59	52.7	53.6	5.1	9.8	36-52	42.7	31	14.6
3	4.00	9.2	41-51	47.0	44.2	16.3						11	21-44	38.2	24.1	10.6
4	6.00	8	42-52	45.2	38.5	18.5						14	35-55	40.1	40.1	33.7
5	0.30	0	0													
6	0.60	12.6	40-55	45.1	34.0	2.6						9.2	30-56	44.3	43.4	2.4
7	0.50	0	0									2	30-51	44	37	0.4
8	0.20	0	0									0				
9	4.00	2	39-52	48.2	38.5	3.1						1.2	32-57	48.4	50	2.4
10	1.00	0										2	43-60	50.8	51.6	1.4
11	2.00	0										2.6	43-54	45.9	49	2.5
12	0.04	0														
13a	2.00	0	0	0	0	0	30	40.63	49.8	51.5	30.9	7	32-53	45.8	47.5	6.7
13b	6.00	54	41-46	43.8	45.0	145.8						0				
14	4.00	0					0.3	51-61	54.3	63.3	0.8	0				
15	6.00	9.5	40-55	47.0	45.0	25.7	7.5	39-62	51.6	55.7	25.1	6.5	39-58	44.3	44	17.2
16	5.00	7	41-53	47.4	45.0	15.8	1	41-60	50.9	54.8	2.7	5.2	37-54	41.8	41.2	10.7
						283.8					64.6					112.9

		Marcia opima					*Crassostrea madrasensis*					*Perna viridis*				
Station	Area (ha)	No./m^2	Size range (mm)	Mean size (mm)	Mean weight (g)	Total biomass (t)	No./m^2	Size range (mm)	Mean size (mm)	Mean weight (g)	Total biomass (t)	No./m^2	Size range (mm)	Mean size (mm)	Mean weight (g)	Total biomass (t)
1	5.00	6	22-37	31.6	11.3	3.4	0									
2	4.80	9	36.45	40.3	19.2	8.3	0									
3	4.00	10.4	21-39	32.4	12.4	5.2	0									
4	6.00	6	22.39	32.8	12.5	4.5	0									
5	0.30	0					115	52-95	70.1	54	18.6					
6	0.60	5	14-48	22.4	8.1	0.2	0									
7	0.50	0					27	57-73	66.2	57	9.2	16	60-75	65	35	2.8
8	0.20	0					46	45-76	57.5	47	4.3	8.6	36-84	67.9	31	0.5
9	4.00	0					0									
10	1.00	0					520	37-84	49.8	43	9	19.6	95-126	115.5	98	0.8
11	2.00	0					0									
12	0.04	0					0					1.2	116-133	122.7	143	1.7
13a	2.00	0					0									
13b	6.00	0					0									
14	4.00	3.2	26-38	32.3	12.1	4.1	0									
15	6.00	2	36-44	39.6	19.1	5.1	0									
16	5.00	0														
						30.8					41.1					5.8

clams in combination with the larger ones were recorded only in the 6th station.

Crassostrea madrasensis

The edible oyster *C. madrasensis* was distributed only in four stations. The fishing harbour, wharf, granite stones opposite to the port office, laterite stones and the granite stones in the inter-tidal region along the bank of the western side of the harbour extending to a stretch of about one kilometre formed a good substratum for settlement of oysters (5th and 7th stations). There was a moderate settlement of oysters underneath the culvert (station 8) but sparsely distributed on either side of the culvert in the Buckingham canal. Settlement of oysters were noted on the granite stones of the lock area (station 10).

These oysters also occurred near the villages of gummaladippa and Lingapuram areas, but were very sparse. The oyster biomass was estimated to be 41.1 t in 1.01 ha area which formed 7.6% of the bivalve resources of the estuary.

Among all the stations, the highest population was noticed in the lock area where the population constituted an average of 520 oysters per m^2 and the total biomass was estimated to 9 t. The second thickest bed was in station 5 and the density of population was 115 per m^2 forming a total biomass of 18.6 t. The density of oyster population was very sparse in the other two stations.

The size of the oysters ranged between 37 and 95 mm and the maximum number was of size above 70 mm, recorded in station 5. Though the oyster population was thick in the lock area, the mean size of the oysters was only 49.8 mm. Among the 4 stations, the male oysters were found to be dominant in three stations namely 5, 7 and 10, whereas in 8^{th} station, females outnumbered males. Gonad studies revealed that majority of the oysters were in the maturing stage (44%) and the ripe and spent ones were 33% and 23% respectively.

Perna viridis

Mussels were recorded only in four stations (7, 8, 10 and 12). The total mussel biomass estimated from this estuary was 5.8 t forming 1.1% of the bivalve population of this estuary. The granite stones along the northern bank of the estuary on the western side of the fishing harbour formed a good substratum and underneath the culvert in station 8 also showed sparse distribution of mussels. The granite stones and the concrete structures in the lock area of the Buckingham canal (10^{th} and 12^{th} stations) formed a good substratum for both oysters and mussels. The population density of mussels was comparatively high (19.6 per m^2) and they were very sparsely distributed on laterite stones and bunds.

The size of the mussels varied in all the stations surveyed; smaller ones (36 - 84 mm) recorded in station 7 and 8 whereas in lock area and bunds, the mussels were comparatively larger (95-126 mm to 116-133 mm respectively). Stages of gonad revealed that majority of males and females were in the ripe condition. Males were dominant in the population. The percentage edibility was 38.4.

Fishery

There was no regular edible oyster fishery in Kandleru Estuary. However, at times seasonal fishery was conducted exclusively for shells in lime industry. During the period of investigation, totally 24 heaps of oyster shells forming about 20 t were recorded near Gummaladippa village. About 15 t of harvested oysters were also recorded on the eastern side of Buckingham canal which were kept ready for transportation. The edible oysters and mussels are fished in recent times to feed the shrimp in nearby shrimp ponds. The meat is sold at the rate of Rs. 30/- per kg.

Clam fishery is being carried out in Kandleru Estuary for shells and clam meat to be supplied to the shrimp farmers. The following species contributed to the fishery. *A. granosa* formed 50%, *M. casta* 30%, *M. opima* 10%, *M. meretrix* 5% and other molluscs 5%. In the bar-mouth, 20 to 25 persons were engaged regularly in clam fishing from Muthukoor village. Each person could collect about 50 to 60 kg of clams per day. Meat is collected by shucking the clams and sold at the rate of Rs. 30/- per kg and shells are sold separately to the shell buyers. Clam fishery is also regularly conducted at Lingapuram village, the southernmost region of Kandleru Estuary. The composition of the fishery was mainly *M. casta*, *A. granosa* and *M. meretrix*. About 20 to 30 people were engaged in collecting the clams regularly in this area.

The Kandleru Estuary is a prominent estuary for bivalve population along south Andhra Predesh coast. There is a good population of clam *M. casta* in the Buckingham canal. The whole population is fished and replenishment is very slow. Since the shrimp industry emerged around the estuary to a large extent, and the demand for the clam meat forced the people to exploit all the bivalve resources for giving it as a natural feed to the shrimps. As a result of indiscriminate fishing in all the estuaries along Andhra coast, the bivalve population is dwindling, which may lead to depletion of stocks.